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RELATIONSHIP BETWEEN BONE CYSTS AND THE IRREGURALRITY OF THE CONTOUR OF THE FEMORAL CONDYLE ON MRI

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Purpose: Magnetic resonance imaging (MRI) started to be used for evaluation of osteoarthritic knee (KOA) severity. We have developed a new method, the Irregularity Index System (IIS), to semi-automatically measure irregularity of the contour of the femoral condyle using standard sagittal proton-density-weighted MR images and demonstrated that the Irregularity Index could reflect the severity of KOA. Unique feature of this method is that irregularity of contour rely solely on pathological changes occurred in the subchondral bone of the femoral condyle. On the other hand, the Whole-Organ Magnetic Resonance Imaging Score (WORMS) is representative evaluation method of KOA semi-quantitively and was reported to be a reliable evaluating method. Big difference between the IIS and the WORMS is that WORMS deals with eight items (tissues) including cartilage, bone marrow, meniscus, synovium, etc. Although basic idea between the two methods is different, both methods had almost the same level of correlation to clinical knee score.The purpose of this study was to compare the two methods especially to examine what items of the WORMS affects the IIS score.
Methods: The subjects were recruited from the patients who visited our hospital for treatment of KOA. The inclusion criteria were medial-type OA knees with ≥ grade II in Kellgren/Lawrence (K/L) grading. Twenty-five patients (25 knees) with a mean age of 69 (range, 58 to 77) years old that consented to participate in this study were enrolled. All patients underwent antero-posterior, weight-bearing x-ray at their first visit, and they were graded according to the K/L grading. They were also clinically examined and were scored with the Japanese Orthopaedic Association OA knee score (JOA score) and the Japanese Knee Osteoarthritis Measure (JKOM). All patients underwent MRI of the affected knees within 2 weeks of their first visit. MRI was performed with a 1.5-T scanner (Signa, GE medical systems) equipped with a knee surface coil. The sequence suitable for the IIS and the WORMS were determined by previous studies. Correlations between the IIS or the WORMS and the clinical scores were analyzed with Pearson's correlation coefficient. Relationship between the items of the WORMS and the IIS as well as the clinical scores were analyzed with regression analysis. Statistical significance was defined as $p< 0.05$. All statistical analyses were performed with Statview 5.0 (SAS Institute Inc., Cary, NC).
Results: Both the IIS and the WORMS demonstrated strong negative correlations with JOA (r= -0.75, $p< 0.0001$; r= -0.79, $p< 0.0001$, respectively), and moderate positive correlations with JKOM (r= 0.40,p=0.04; r= 0.47, p= 0.008, respectively).
The IIS has statistically significance with the medial femora-tibial joint (MFTJ) bone cysts (p=0.004) of the WORMS and the other items were not correlated. The JOA score has statistically significance with MFTJ-cartilage (p=0.044) of the WORMS and the JKOM has with PF-cartilage (p=0.036). The other items of the WORMS were not correlated with neither of the JOA score and the JKOM.
Conclusions: Both the IIS and the WORMS had correlations with the clinical scores. Among several items of the WORMS, only bone cysts were related to the IIS. This would be consistent with our previous study that showed strong correlation between the IIS score and density of bone resorption pits (BRP) formed in the subchondral bone using specimens derived at the time of total knee arthroplasty because not all but part of the BRP would account for bone cysts on MRI examination.

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QCT OF THE KNEE FOR THE QUANTIFICATION OF SUBCHONDRAL BONE MINERAL DENSITY AND STRUCTURE IN NORMAL SUBJECTS AND OA PATIENTS: PRELIMINARY RESULTS

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Purpose: To use a new quantitative computed tomography (QCT) approach in the knee for the measurement of BMD and parameters related to bone structure to differentiate normal subjects and OA patients.
Methods: We developed quantitative computed tomography (QCT) of the knee. The patient is scanned in decubitus position with the target knee as straight as possible. A calibration phantom is positioned below the knee. A high resolution (Siemens UHR protocol, 120 kV, 170 mAs, 0.5 mm collimation, 13cm FOV) with two reconstructions (medium U40 and high resolution U70 kernel) is used. The U40 reconstruction is used for the segmentation and the determination of BMD, the U70 reconstruction for quantification of structural parameters. Based on the 3D segmentation of the periosteal and endosteal bone surfaces, the growth plates and the definition of anatomical coordinate systems (ACS) three volumes of interest (VOI 1-3) were defined in each epiphysis that automatically follow the bone cartilage surface (see Figure). In addition a smaller subcortical VOI (subcort) was also used. All VOIs are further divided in medial and lateral sub VOIs. For each VOI, BMD and several structural parameters, such as homogeneity, local and global structural anisotropy and fractal measures are derived. In addition joint gap width and volume are quantified. In an ongoing study we compare results for healthy volunteers and patients with AO (KL 2-3). In this abstract preliminary results of the first 10 subjects per group are included. More data will be available at the time of the conference
Results: Significant differences between healthy subjects and OA patients were so far found in the subcortical VOI of the tibia (see graph, all shown differences were significant) but not in the other VOIs, however, for the analysis medial and lateral compartments were not distinguished so far. The exception were fractal measures that showed significant between group differences in all tibia VOIs.
The highest difference was found for the joint gap width, BMD, grey value homogeneity and the fractal index.

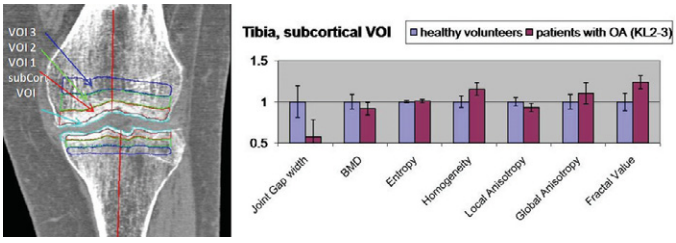

Figure 1. Left: epiphseal VOIs in the tibia and femur. Right: BMD and parameters related to bone structure for 10 healthy subjects and 10 OP patients. Data are scaled so that all results fit in one graph (results for healthy volunteers were arbitrarily set to 1 and results for OA subjects were scaled accordingly.

Conclusions: QCT of the knee may be a promising method to quantify subchondral BMD and bone structure to improve the diagnosis of and treatment monitoring of OA In our so far limited analysis OA altered BMD and bone structure in the subcortical VOI of the tibia.
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CYST VOLUME IN THE ACETABULUM AND FEMORAL HEAD DECREASE AFTER PERIACETABULAR OSTEOTOMY

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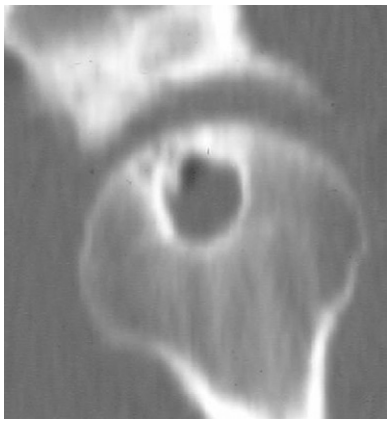
Purpose: Bone cysts in patients with hip dysplasia, is the result of degeneration or defects of the articular cartilage and elevated local stresses in the subchondral bone. In a series of consecutively included patients scheduled for periacetabular osteotomy (PAO), we examined how many had acetabular or femoral head cysts preoperatively and measured the volume of these cysts. 1 and 2½ years after PAO we re-measured the volume of the cysts to investigate whether the cysts developed further after PAO.
Methods: 24 females and 4 males with hip dysplasia had the hip magnetic resonance imaged (MRI) before PAO, 1 and 2½ years and after surgery. The location and number of cysts were noted and the total cyst volume in each patient was estimated with a design-based stereological method: Cavalieri's Principle. Two angles were measured on pre- and postoperative AP radiographs: center-edge (CE) and acetabular index (AI) angle.
Results: 11 of 28 patients had acetabular cysts preoperatively (21 cysts, mean total cyst volume/patient 3.44 cm^3, SD 6.712) and 1 patient had a cyst in the femoral head (volume 8.05 cm^3). One year after PAO, 13 patients had acetabular cysts (19 cysts, mean total cyst volume/patient

1.96 cm^3, SD 3.97) and 2 patients had femoral head cysts (4 cysts, mean total cyst volume/patient 3.98 cm^3, SD 4.10). 2½ years after surgery 13 patients had acetabular cysts (16 cysts, mean total cyst volume/patient 0.96 cm^3, SD 1.70) and 2 patients had femoral head cysts (4 cysts, mean total cyst volume/patient 0.80 cm^3, SD 0.72). Mean total acetabular cyst volume/patient decreased significantly from 1 year to 2½ years after PAO = 0.04. All acetabular cysts were located anterolaterally in the acetabulum except for one that was posterolateral. The femoral head cysts were positioned anterolaterally and anteromedially.
The radiographic evaluation on preoperative and postoperative radiographs in the 28 hips showed that the CE angle increased from mean 13 (-27 to 35)° to mean 31 (20 to 41)° after PAO, and the AI angle decreased from mean 18 (7 to 39)° to mean 2 (-4 to 10)°.



Conclusions: In conclusion, the radiographically measured angles demonstrated optimal surgical correction of the acetabulum at PAO. The mean total cyst volume/patient decreased significantly between 1 and 2½ years after PAO. We believe this is a result of decreased local stresses in the subchondral bone after PAO which also indicates that redirection of the acetabulum reduces the risk of progression of osteoarthritis in the operated hip.

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QUANTIFICATION OF TRABECULAR TIBIAL BONE STRUCTURE FROM LOW-FIELD MRI

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Purpose: The pathogenesis of osteoarthritis (OA) is a complex chain of events in the whole joint, eventually leading to pain and disability. Cartilage loss and overall bone remodeling are central in the progression of OA, and have been studied in many ways. The trabecular bone structure has been investigated mainly from high-resolution magnetic resonance imaging (MRI), micro computed tomography (μCT), or radiographs. We investigated the feasibility of quantifying OA-characteristic bone structure from low-field MRI.
Methods: The 21-month longitudinal study included 159 subjects prospectively selected to include a large range of ages and degrees of OA. After exclusion of scans due to acquisition errors, 311 knee scans were included. The population characteristics were: age 56±16, BMI 26±4, 47% female, and 19% with radiographic OA (Kellgren and Lawrence, KL>1). The KL score was determined from load-bearing radiographs in semi-flexed position using the SynaFlex (Synarc). MRI scans with near-isotropic voxels were acquired using a Turbo 3D T1 sequence from a 0.18T Esaote scanner (40° FA, TR 50ms, TE 16ms, scan time 10 minutes, resolution 0.7mm × 0.7mm × 0.8mm). The medial tibial cartilage compartment was segmented automatically by a voxel classification framework and used to determine a region-of-interest in the subchondral medial tibia from 3 to 14 mm below the cartilage covering a load-bearing region of the trabecular bone (see Figure 1). A total of 534 potential bone structure features were designed using Gaussian derivatives at multiple scales. A machine learning based framework using cross-validation and bootstrapping was used to automatically select the features for a linear discriminant classifier including 20 features. The resulting bone structure marker was analyzed cross-sectionally for the ability to separate healthy and OA knees by the area under the receiver-operator characteristics curve (AUC). The statistical significances of AUC scores and differences in-between were tested using DeLong's test.

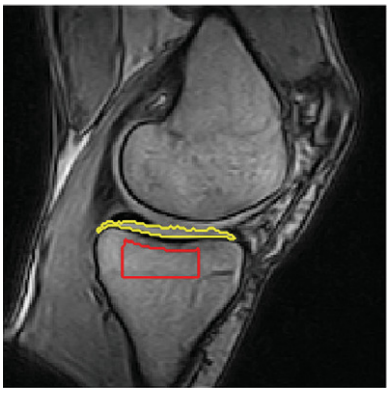

Figure 1: Sagittal view of a knee scan. The red outlined area is the automatically extracted ROI and the yellow outlined area is the given cartilage segmentation.

Results: Separating healthy and OA knees based on the selected bone structure features resulted in median AUC of 0.77, p=0.0059. The best single bone feature among the 534 features resulted in AUC of 0.73, p=0.0166.
Conclusions: The limited spatial resolution of low-field MRI makes direct analysis of the trabecular rod/plate structure infeasible. However, the results demonstrated the possibility of separating healthy and OA knees from the tibial bone structure. It was possible to quantify a trabecular structure marker related strongly to the presence of OA. Furthermore, selecting a set of appropriate features demonstrated better results than including the best single bone structure feature.
More research is needed to determine the clinical features that this marker describes - potential candidates are bone marrow lesions, growth zone characteristics, or possibly even textural patterns related to the rod/plate ratio even if the individual trabeculae are not visible.

Inflammation and Immunity

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INCREASED INFLAMMATORY CYTOKINE GENE EXPRESSION IN THE SKELETAL MUSCLE OF PATIENTS WITH SEVERE KNEE OSTEOARTHRITIS

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Purpose: Loss of muscle strength, particularly in the quadriceps, and impairment of functional capacity are common characteristics of people with knee osteoarthritis (OA), which is a painful, chronic and progressive condition. Patients with OA are characterised by increased inflammation and sensitized nerves, resulting in increased pain. To date, studies have focused on the inflammatory responses within the synovial membrane, synovial tissues and articular chondrocytes, yet the inflammatory pathology in skeletal muscle is not clear. The aim of this study was to examine the effect of severe OA on inflammatory genes in skeletal muscle that regulate muscle mass compared to asymptomatic older people
Methods: Participants: 19 patients (mean ± SEM, age 69.9±1.5 year and BMI =29.9±0.9 $kg{\cdot}m^{-2}$) with severe knee OA scheduled for knee replacement surgery, 17 age-matched asymptomatic (MA) older people (age= 66.7±1.8 year, BMI=29.8±1.2 $kg{\cdot}m^{-2}$) and 12 asymptomatic young (Y) individuals (age 25.1±1.1 year, BMI 23.6±1.0 $kg{\cdot}m^{-2}$). Muscle samples from the *vastus lateralis* were taken from patients with knee OA during their knee replacement surgery, and from the MA and Y using a needle biopsy technique, at rest and in a fasting state. Real-time polymerase chain reaction (RT-PCR) was performed to measure the mRNA abundance for the